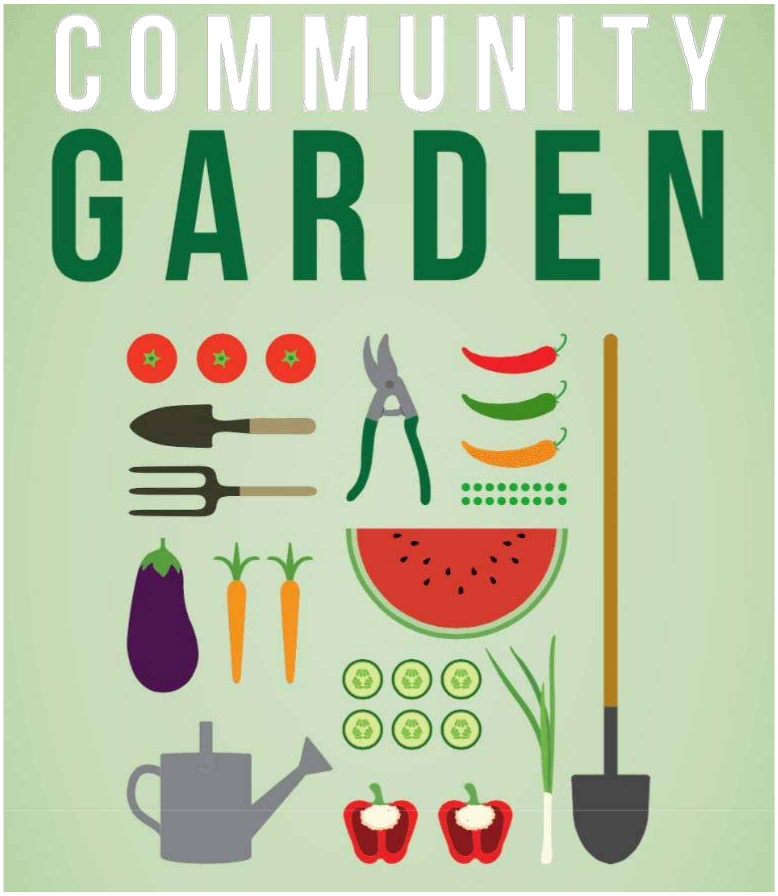

Assessment of Heavy Metals in the Arbutus Greenway, Vancouver

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Executive summary:

The Arbutus Greenway in Vancouver is 8.8 kilometers from West 1st Avenue in the north to Milton Street in the south. From 1902 to 2001, the Arbutus Greenway served as a railway for regional freight and interurban passenger transport service in Vancouver. In March 2016, the City of Vancouver purchased the Arbutus Corridor from the Canadian Pacific Railway (CPR) with plans to build this corridor into a greenway throughout the city, including walking, wheeling, cycling and gardening, to allow the public to enjoy leisure time with family and friends. Based on this background, it is particularly important to study the soil quality in this area. Five random sites were selected in Zone 1 of the Arbutus Greenway. The pH, ash content and heavy metal concentration of the soil were determined. The metals Cd, Co, Cr, Cu, Ni, Pb and Zn were selected as important in relation to human exposure. The concentration of Co, Cr and Ni were below Canadian Agricultural standards of contamination; only one soil sample exceed the standard of Cd by 35%; three samples of Zn exceeded the standard by 14%, 4% and 18%; there are three samples that exceeded the standard of lead. Although there is no major concern of heavy metal contamination at the present time, there are indications that some metals are approaching and exceeding the Canadian standard, especially lead. It is recommended that community gardeners should continue to monitor the site and vegetation, and bring in soil from certified suppliers to the raised bed for vegetable production.

1. Introduction

Food is the foundation of people's lives and the basis of social and economic development. Food-related issues have always been valued by people, and food security is considered to be the most important factor. Initially, the term food security was used to describe whether a country has enough food to meet the needs of its citizens, but with increasing social concerns, the connotation of food security has evolved. The FAO's definition of food security states that "Food security exists when all people at all times have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2013). This definition includes three dimensions: the first is sufficiency, which means that people have right to access enough food to meet their daily demand. The second is safety, which means that people can get food, which is safe, healthy, nutritious and free with contaminates. The last is preferences, which refer to choices people can make about food they eat. This includes the type of food, location and method of production. Our nutritional status, health, physical strength and intelligence depend on what food we eat. Although food production has grown significantly over the past 50 years, in 2009, there were still over one billion people in the world suffering from malnutrition (FAO, 2009). With the continuous health concerns by society, more and more people are paying attention to food security issues, and food security issues have become one of the top issues that governments need to address.

Concurrently, the development of urbanization also had a great impact on food safety. Urbanization is the inevitable trend of human society development and it is also the inevitable result of economic and technological development. Increasingly, more and more people choose large cities as their main habitat. In the recent 100 years, the population of urban areas has increased from 15 to 50% of total global population (Deelstra and Girardet, 2000). As of 2006, only 20% of Canada's population lives in rural areas. Urbanization has led to the alienation of land, which originally was used for agriculture and urbanization. This has not only affected the area formerly used for agriculture but also led to the competition for water and energy, the natural resources that affect the ability of food production (Godfray et al., 2010). As stated, the urban population is close to half of the world's population, which means that ensuring food security for the urban residents is of great significance. Urban residents are less likely to produce their own food but consume food which has been transported a long-distance to the urban areas, and more processed foods are consumed than rural areas (Campbell, 2004). Thus, urban agriculture is gradually emerging as a unique form of agriculture and community gardens have been adopted by people. More and more people choose to start their own gardening activities (Twiss et al., 2003).

2. Community Gardens:

2.1 Definition

According to Tidball and Krasy (2007), the definition of community garden is: “Community gardens are plots of land used for growing food by people from different families”. Thus, community gardens provide an important place for people to deal with food security issue in a collective way.

2.2 Advantages:

In reviewing the literature, the following advantages of community gardens were highlighted:

Nutritional benefits; community welfare; interdependence with rural agriculture;

1) Human health: community garden can enhance positive dietary habits, increase fruit and vegetable consumption. (Heim et al., 2009）

2) Mental Health: improvements in effective well-being, psychological symptoms, tension or distress following a gardening intervention (Austin et al., 2006; Heliker et al., 2000）.

3) Social networks: a community garden can bring neighbors together and strength social ties. Community gardens also give people with different cultural backgrounds opportunities to understand each other. Community gardening can also involve multiple empowerment processes (Doyle and Krasny, 2003).

4) Economic benefits: In addition to the cost-saving benefits associated with growing one’s own produce, gardens also create job and training opportunities and provide economic benefits for those who are willing to sell produce to local restaurants, at farmer’s markets (Garrett, 2015).

5) Environmental well-being:

One direct benefit is carbon sequestration. This entails removal of existing carbon from the atmosphere and has been called the “reverse greenhouse effect” (Meadows 2000), and

6) Food source/food security: Gardens generate a wide variety of fresh produce often not available or extremely expensive in local food stores. For example, 501 West Philadelphia Community Gardens produced $1,948,633 worth of fruits and vegetables in a single year (Hannah & Oh, 2000).

2.3 Health Concerns

Each community garden may face different challenges, but in general, there are a few main challenges that are common: these include food security issues, garden management issues and waste disposal issues (Houlberg, 2014). This study suggested that the main research finding was the possible impact of community gardens on food safety issues. The issues considered were:

1) Soil contamination: many studies have shown that there is a potential of heavy metal contamination in community gardens. According to Rebecca’s research in 2014, she found that Pb and Ba exceeded 9%-12% of health-based guidance values in garden beds. Often a site’s history provides a clue to the contaminants that linger in the soil. Former parking lots and car washes often carry heavy metals, polycyclic aromatic hydrocarbons (PAHs), and petroleum products. Demolished commercial or industrial buildings may leave behind asbestos, polychlorinated biphenyls, petroleum products, or lead-based paint chips, and dust. High-traffic roadways have a legacy of lead and PAHs from vehicle exhaust (EPA, 2011).

2) Traffic pollution:

Particulate matter emitted by vehicles may undergo dry and wet aerial deposition on nearby vegetation and soils. Infiltration can occur into surface soils by road runoff or traffic spray water onto vegetation and soils. Particulate matter may collect in road puddles, dry out, and become re-suspended by wind and traffic abrasion. Traffic pollutants can, therefore, affect both roadside soils and vegetation by either direct emission (from exhausts) or indirect emissions from vehicle and road wear (Dack, 2015).

Sulphur dioxide and other gases (SO_2, NO x, O_3) and fine particulate matter (PM10), may also be a major problem for urban vegetation which affects nutrition, yield and quality (Bell et al., 2011).

Among all the potential pollutants, heavy metals are one of the most persistent pollutants in the soil and have long-term toxicity (Jolly, 2013). Unlike organic materials, heavy metals do not decay over time. Lead and other heavy metals in the soil can enter the human body through respiration or ingestion. People who eat the produce grown in contaminated soil may have heavy metals enter the human body and accumulate, and the lead levels can cause serious harm to the human body (Massas, 2013).

3. Study Context

3.1 Community Gardens in Vancouver, BC

There are over 110 community gardens in Vancouver, located in city parks, schoolyards and private property.

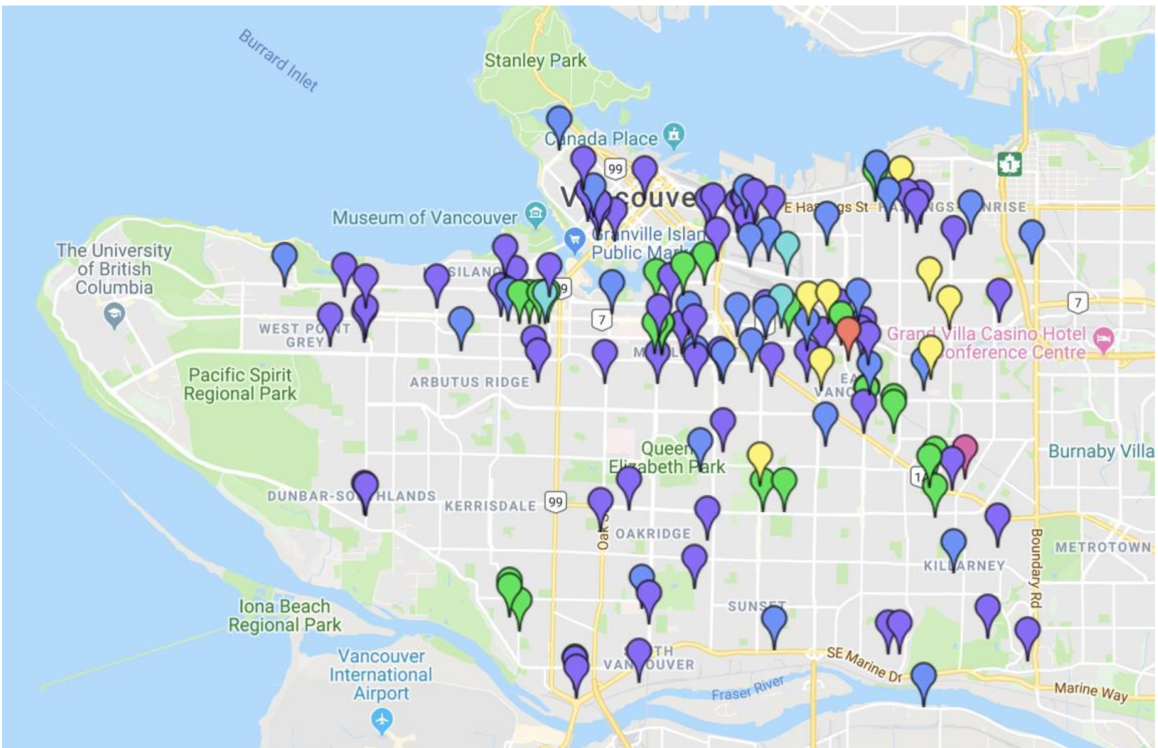

Figure1. Community gardens in Vancouver

(https://vancouver.ca/people-programs/community-gardens.aspx)

The overall aim of this study was to provide an evaluation of potential heavy metal contamination along a recently de-commissioned railroad track in Vancouver. This particular section has a history of small scale raised bed community gardens. This study focuses on Vancouver transportation corridor, the Arbutus Greenway, as a case study.


KITSILANO BEACH
Cypress St
False Creek
GRANVILLE ISLAND
4th Ave
KITSILANO
Broadway
10th Ave
FAIRVIEW
MacDonald St
Arbutus St
Burrard St
16th Ave
SHAUGHNESSY
ARBUTUS RIDGE
King Edward Ave
QUILCHENA
33rd Ave
Larch St
37th Ave
Granville St
Oak St
41st Ave
KERRISDALE
45th Ave
49th Ave
SOUTH GRANVILLE
West Blvd
SW Marine Dr
57th Ave
59th Ave
64th Ave
67th Ave
68th Ave
70th Ave
MARPOLE
SW Marine Dr
ARBUTUS GREENWAY
Connections to Seawall & Canada Line
Cycling Routes
Cycling Connection
Transit
Park
Skateboarding
Commercial District
Community Garden
Viewpoint
Community Centre
Museum
Toilet
Mobi Stations
Current
Coming this year

Figure2. Arbutus greenway map

(https://vancouver.ca/files/cov/arbutus-greenway-printable-map.pdf)

3.2 Arbutus Greenway History

From 1902 to 2001, the Arbutus Greenway served as a railway for regional freight and interurban passenger transport service in Vancouver. The Arbutus Greenway is 8.8 kilometers in length from near West 1st Avenue in the north to Milton Street in the south. In March 2016, the City of Vancouver purchased the Arbutus Corridor from the Canadian Pacific Railway (CPR). The City plans to build this corridor into transportation greenway for the city, including walking, wheeling, cycling and future streetcars (Arbutus Greenway Design Vision, 2018). Thus, people will be able to enjoy leisure time with family and friends in urban environment. As an interim condition, the City built a temporary path for walking, wheeling and cycling, allowing people to become familiar with the corridor before further development of the Arbutus Greenway. In 2017, the City began to design the Arbutus Greenway (Arbutus Greenway Implementation Strategy).

As stated, heavy metals are the most common and most intensively studied chemical substances in environmental contamination research. The railway area is considered to be potentially contaminated by heavy metals. Many studies have shown that the wear of railway tracks, the burning of diesel electric locomotive fuel and the leakage of goods can emit heavy metals into the air and subsequently deposit them onto plants and soil (Wiłkomirski et al., 2010).

3.3 Arbutus Greenway -West 6th AVE @ Fir Street- West Broadway

For this evaluation the north section of the Arbutus Greenway was selected as the study area. In this area, there exist several community gardens. According to Arbutus Greenway design vision in 2018, the Arbutus Greenway is divided into eight character zones. The study area is Zone 1. The concept of Zone 1 is the “harvest table”, which means this zone will become a place to build the connection with people and urban agriculture (Arbutus Greenway Design Vision, 2018). This zone will keep some the existing community gardens and transform the City Park into places for people to relax and enjoy, allowing people to have picnics and enrich their social life. The important stated vision for this area is the connection between food and people.

Figure3. the Arbutus Greenway Zone1

([https://vancouver.ca/files/cov/arbutus-greenway-proposed-design-information-displays.pdf)](https://vancouver.ca/files/cov/arbutus-greenway-proposed-design-information-displays.pdf)

4. Research Objectives

In this case study, the quality of the soil in Zone1 is particularly important. Random sampling sites in Arbutus Greenway Zone 1 were selected. At each site soil sample were collected to determine the total concentration and available concentration of heavy metals in the soil. The objectives of this study were: 1) to determine the heavy metal concentrations in the soil in this area, compare the results with the Canadian Standards to assess whether there is heavy metal concentration exceeding the standards; 2) to determine the potential transfer availability of heavy metal from soil to vegetation. 3) to determine possible sources of heavy metals, and 4) to propose viable solutions for reducing potential heavy metal hazards.

5. Materials and Methods

5.1 Sites Selection

The Arbutus Greenway Design Vision, Greenway is divided into 8 character zones, as shown in figure 4,

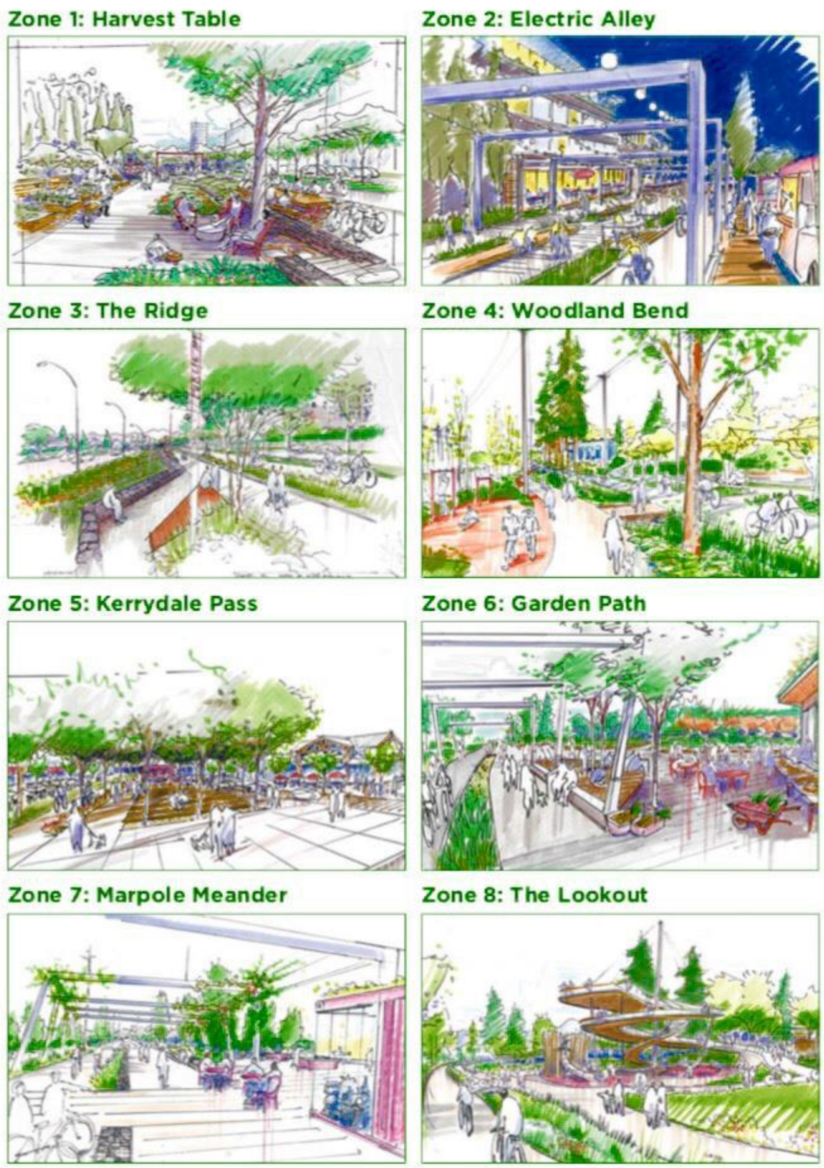

Figure4. the Arbutus Greenway design vision

(https://vancouver.ca/files/cov/arbutus-greenway-design-vision-july-2018.pdf)

Arbutus Greenway Zone 1 extends from West 6th avenue at Fir street to West Broadway. In this area, five randomly selected sites along the corridor were sampled. These sites included four sites in the middle of corridor and one site in the community garden (figure 5). At each site, one sample was collected from the onsite soil and another sample from the raised bed from the community gardens at each site. Soil samples used for analysis were composites of three samples taken from a depth of 0-15 cm.

Table1. Sites information

No.	Information
1	site A sample 1
2	Site A sample 2
3	site B onsite soil
4	site B community garden
5	site C onsite soil
6	site C community garden
7	site D onsite soil
8	site D community garden
9	site E onsite soil
10	site E community garden

Figure5. Sites map

(https://vancouver.ca/files/cov/arbutus-greenway-proposed-design-information-displays.pdf)

Figure6. Design concept of Zone 1

(https://vancouver.ca/files/cov/arbutus-greenway-design-vision-july-2018.pdf)

5.2 Method

5.2.1 pH Analysis

Both pH in water and pH in $CaCl_2$ were determined. The samples were air dried for two days at room temperature prior to the measurements of pH value (Hendershot and Lalande, 1993).

5.2.2 Heavy Metal Analysis

Soil samples for heavy metal determination and other indicators were dried in an oven at 150 ^{O}C. The procedures followed are given in Jackson, 1996; Humphries, 1956. The heavy metals selected were: Cd, Co, Cr, Cu, Ni, Pb and Zn. The agricultural acceptable standards for the heavy metal are from the Canadian Council of Ministers of the Environment (CCME, 2014).

5.2.3 Availability Ratio (AR)

The following formula was used to calculate the availability ratio (AR) of the proportion of each heavy metal that is available to plants (Massas et al. 2010):

$$AR = (C_{ia}/C_{it}) \times 10^2$$

where

C_{ia} The available metal concentration in the ith sampling site

C_{it} The total metal concentration in the ith sampling site.

6. Results

6.1 Soil pH

Table2. Soil pH

Difference between pH in water and pH in Cacl2		
Site	Onsite	Community garden
A	0.33	0.26
B	0.23	0.02
C	0.08	0.02
D	0.79	0.59
E	0.69	0.61

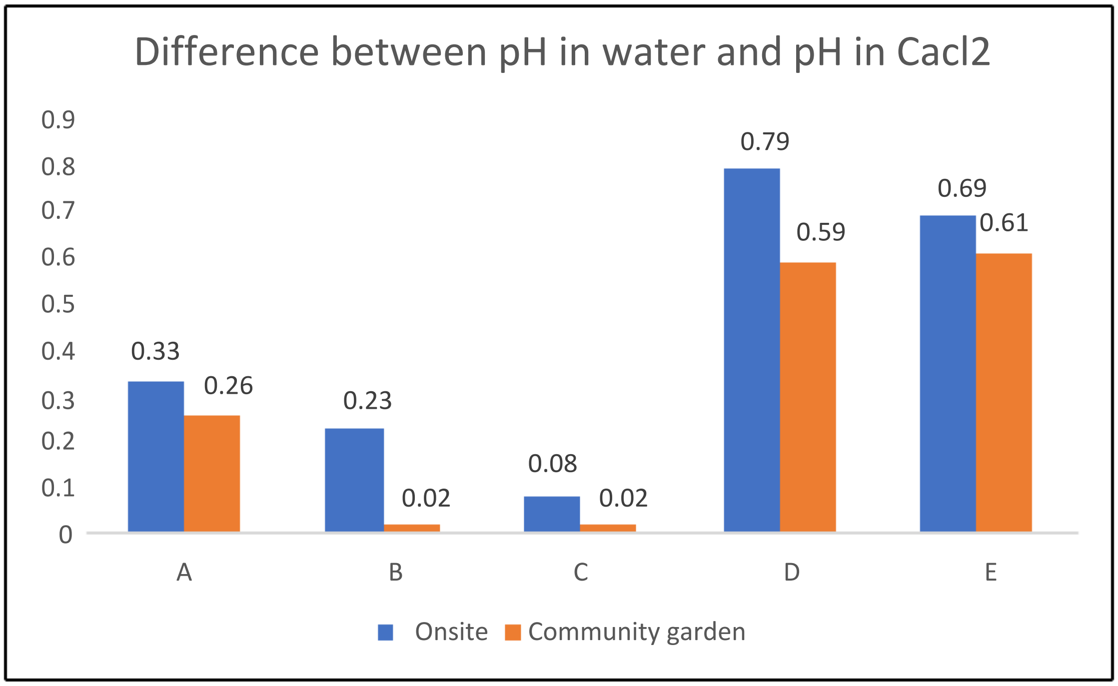

Figure7. difference between pH in water and pH in $Cacl_2$

Figure 7 shows the difference between pH in water and pH in $CaCl_2$ of the onsite soil and Community Garden soil. The difference between pH in water and pH in $CaCl_2$ is an indication of the exchangeable acidity. If the difference is large, it indicates that the exchangeable acidity is large. A difference of 0.5 to 1 pH units is significant. Exchangeable acidity refers to the amount of acid cations (aluminum and hydrogen), occupied on the CEC. When the CEC of soil is high, the soil has strong buffering capacity for pH changes. The pH of soil is one of the most important properties of soil. It controls the availability of essential nutrients and the availability of some trace elements. Too high, or too low pH, affects soil microbial abundance and soil structure. As can be seen from the above Figure 7:

1) Overall, the exchangeable acidity of the onsite soil is larger than the community garden.

2) The pH levels of site A, site B and site C are not very high. The differences in site D and site E are more obvious. Both of values exceed 0.5, which indicate that the exchangeable acidity in these two sites is large.

（Minasny, B., McBratney, A. B., Brough, D. M., & Jacquier, D., 2011)

6.2 Ash content

Table3. soil ash content and organic matter

No.	Ash content	organic matter
1	66.5%	33.5%
2	36%	64%
3	78.5%	21.5%
4	45.5%	54.5%
5	71.5%	28.5%
6	77.5%	22.5%
7	77%	23%
8	51.5%	48.5%
9	79%	21%
10	68.5%	31.5%

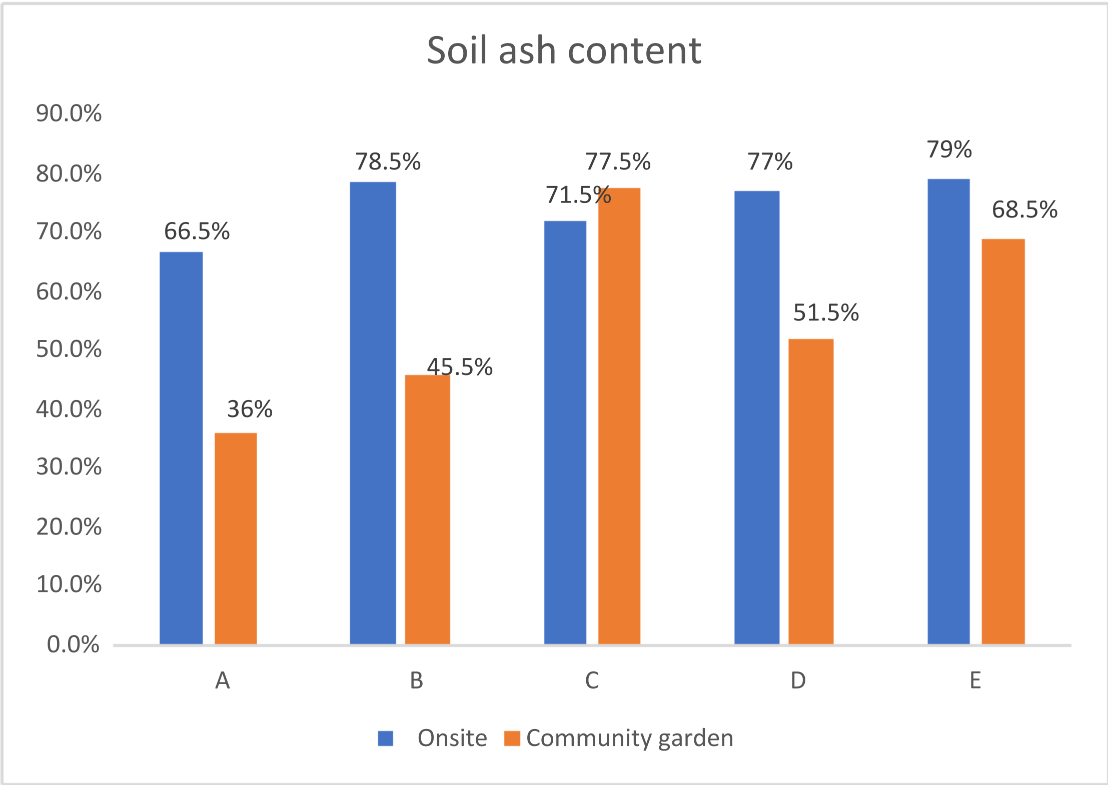

Figure 8 Soil ash content

6.3 Total concentration

6.3.1 Summary

Table4. soil total concentration

	Sample	onsite	community garden	Standard
Cd	**A**	**0.39**	**0.78**	**1.4**
	B	**nd**	**0.79**	**1.4**
	C	**1.89**	**nd**	**1.4**
	D	**1.03**	**0.11**	**1.4**
	E	**nd**	**1.13**	**1.4**
Co	**Sample**	**onsite**	**community garden**	**Standard**
	A	**3.75**	**4.53**	**40**
	B	**5.85**	**4.53**	**40**
	C	**2.97**	**3.95**	**40**
	D	**3.63**	**0.99**	**40**
	E	**4.33**	**4.82**	**40**
Cr	**Sample**	**onsite**	**community garden**	**Standard**
	A	**27.6**	**29.1**	**64**
	B	**27.0**	**35.1**	**64**
	C	**11.7**	**29.3**	**64**
	D	**14.0**	**16.7**	**64**
	E	**22.3**	**25.9**	**64**
Cu	**Sample**	**onsite**	**community garden**	**Standard**
	A	**45.0**	**73.8**	**63**
	B	**62.2**	**94.2**	**63**
	C	**47.6**	**62.4**	**63**
	D	**69.1**	**24.4**	**63**
	E	**47.3**	**80.1**	**63**
Ni	**Sample**	**onsite**	**community garden**	**Standard**
	A	**28.5**	**27.0**	**45**
	B	**28.3**	**30.7**	**45**
	C	**15.3**	**28.1**	**45**
	D	**27.4**	**28.8**	**45**
	E	**26.0**	**30.2**	**45**
Pb	**Sample**	**onsite**	**community garden**	**Standard**
	A	**36.5**	**18.5**	**70**
	B	**139.7**	**44.0**	**70**
	C	**45.5**	**26.3**	**70**
	D	**70.6**	**6.9**	**70**
	E	**159.4**	**185.8**	**70**
Zn	**Sample**	**onsite**	**community garden**	**Standard**
	A	**143**	**285**	**250**
	B	**260**	**239**	**250**
	C	**143**	**186**	**250**
	D	**148**	**134**	**250**
	E	**156**	**295**	**250**

6.3.2 Total concentration

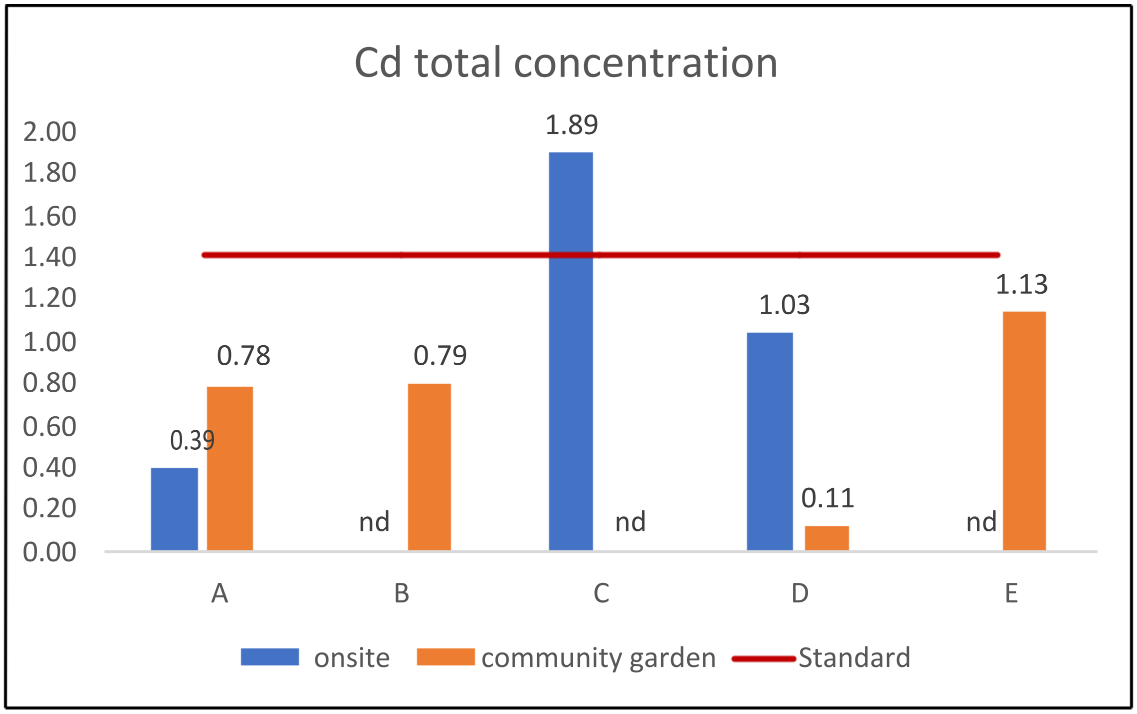

Figure 9. Cd total concentration

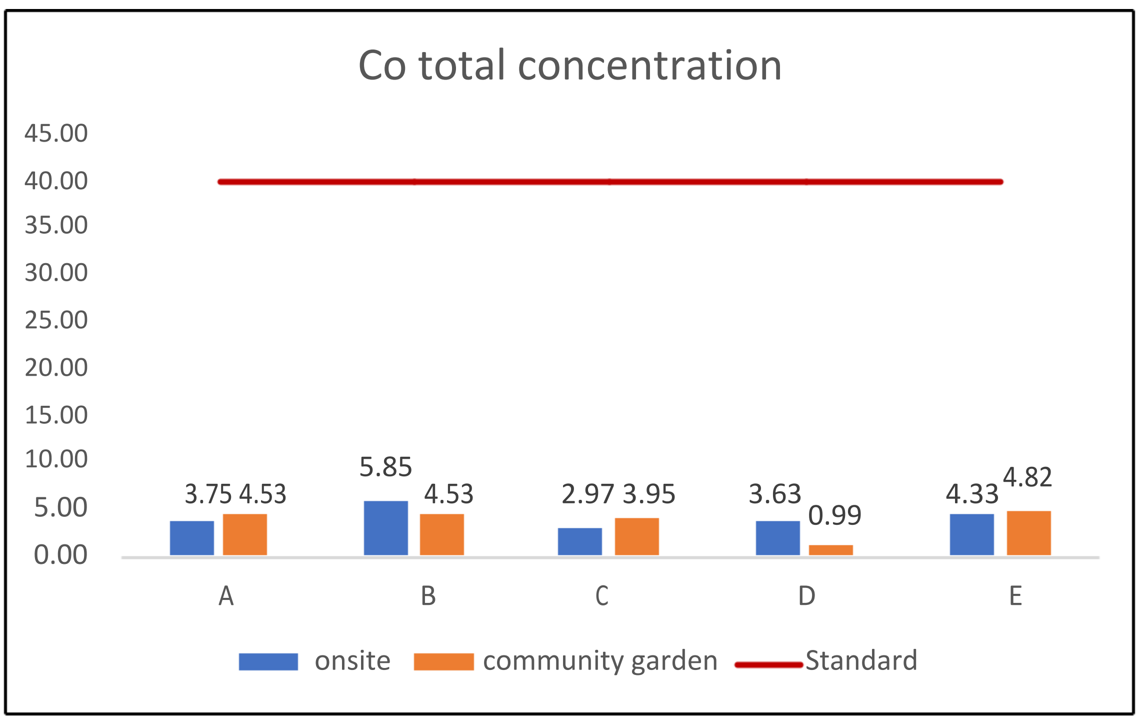

Figure 10. Co total concentration

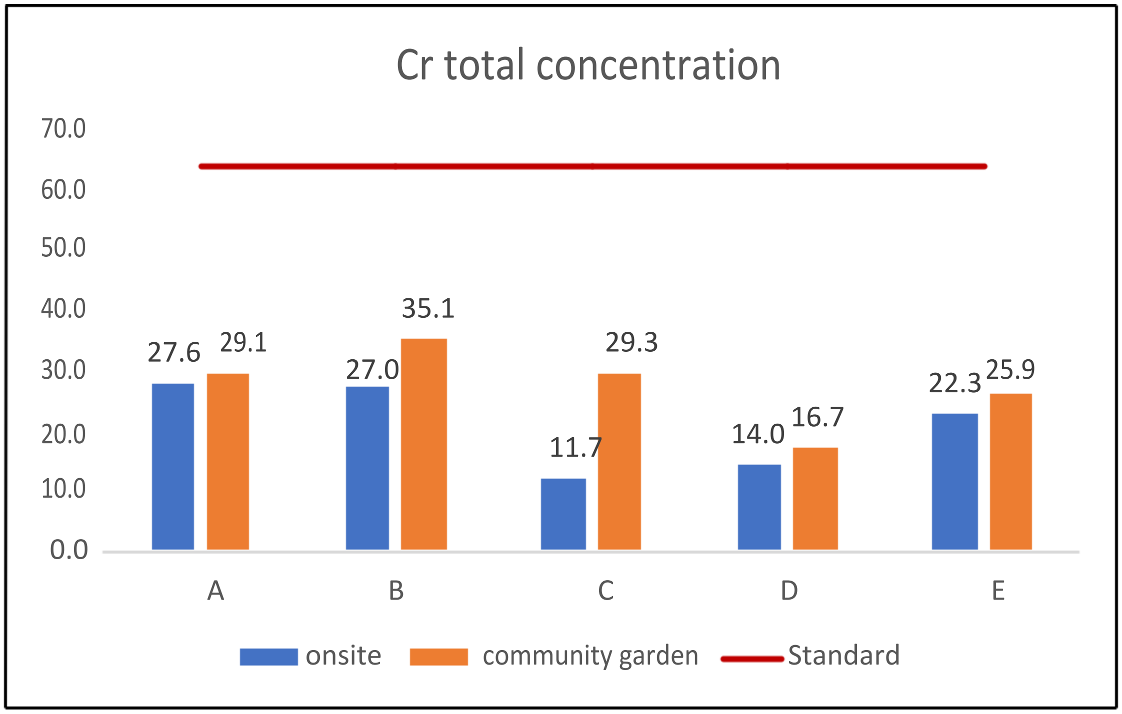

Figure11. Cr total concentration

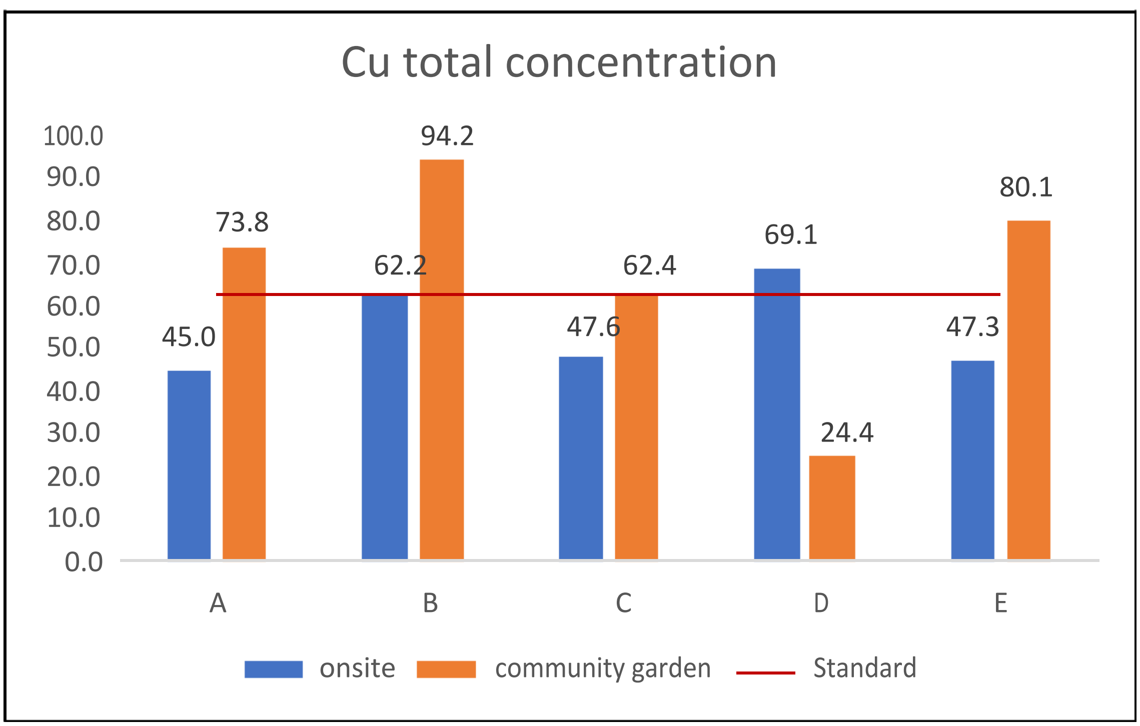

Figure12. Cu total concentration

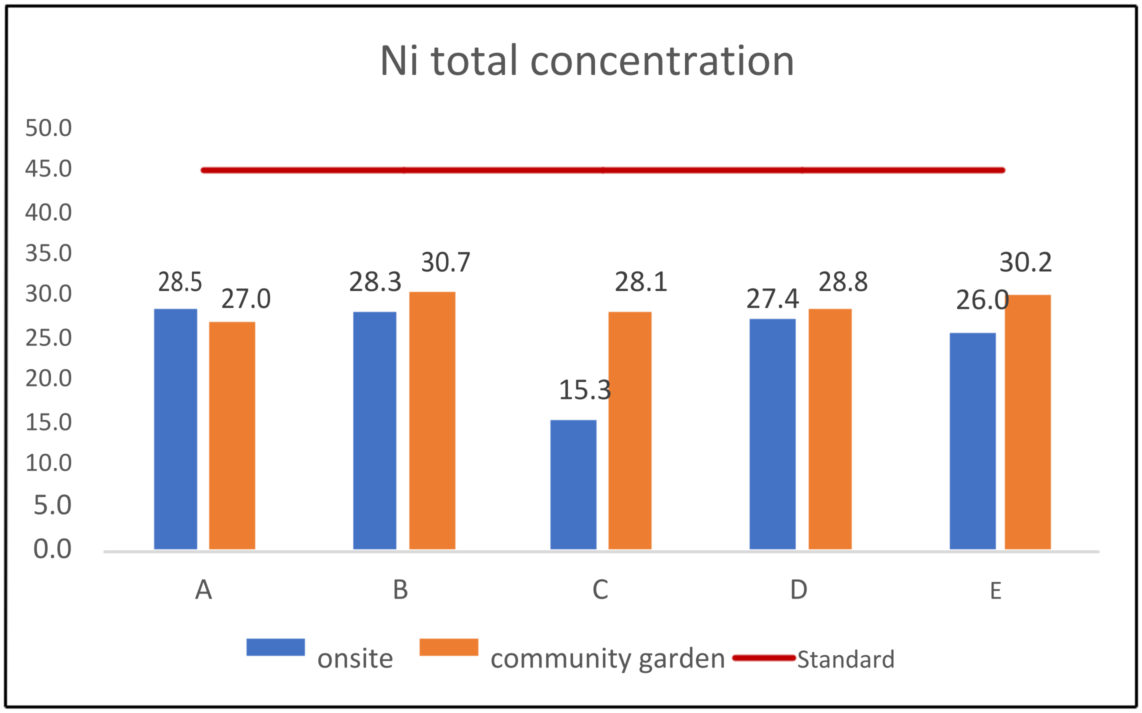

Figure14 Ni total concentration

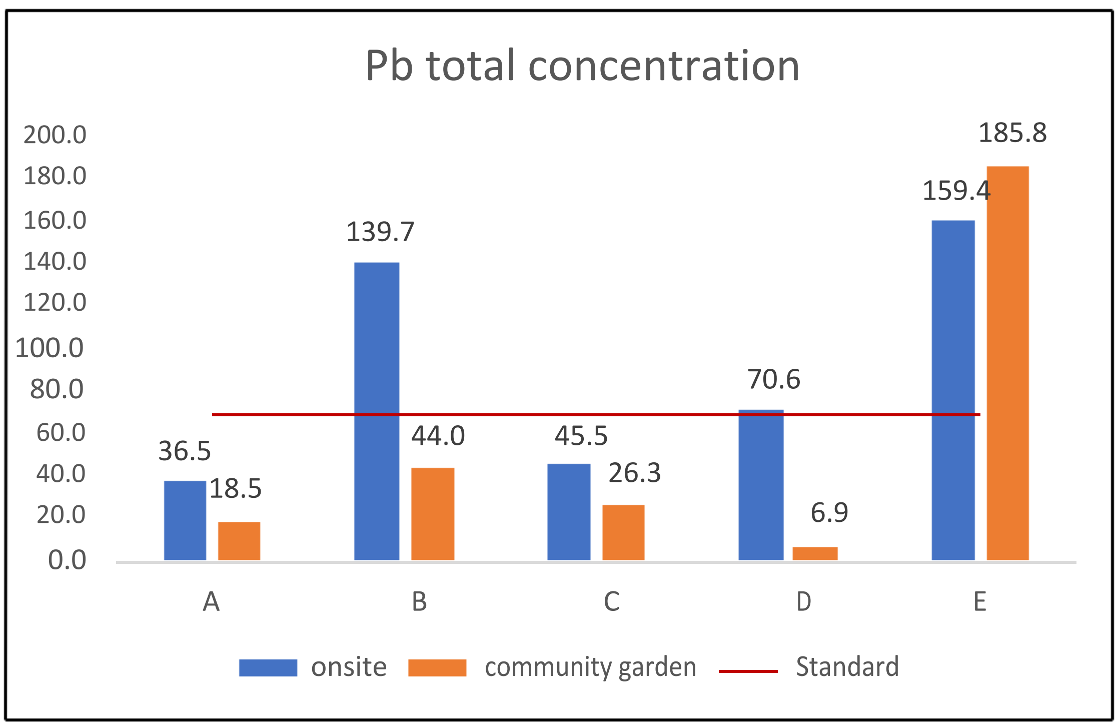

Figure 15 Pb total concentration

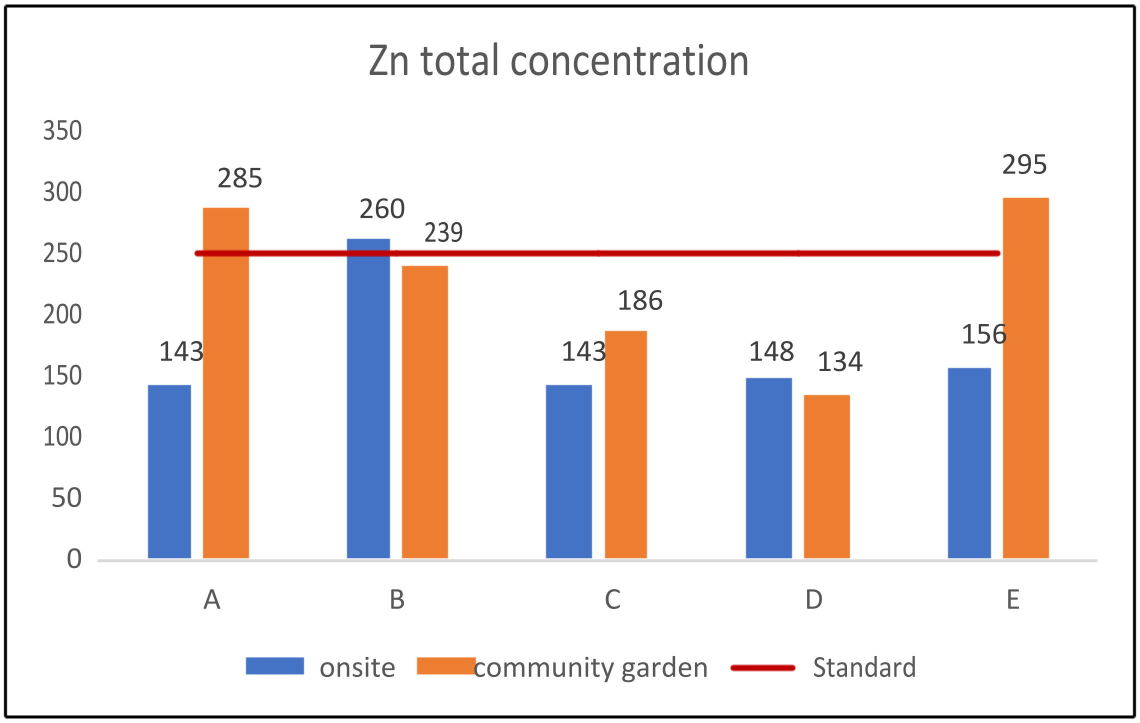

Figure 16. Zn total concentration

As can be seen from the figures, some samples' total concentration of Cu, Cd, Pb and Zn exceed the Canadian standard. Over 50% of the samples exceed the standard for Cu, 10% samples exceed Canadian standard for Cd, 30% samples exceed the Canadian standard for Pb; and 30% samples exceed Canadian standard for Zn. One of the most element of concern is Pb, total concentration of community garden in site E was found to be over the Canadian Standard by almost 165%.

6.4 Available concentration

6.4.1 Summary

Table 4 Availability concentration

	SAMPLE	onsite	community garden
Cd	A	0.30	0.36
	B	nd	0.09
	C	0.38	nd
	D	0.20	0.10
	E	nd	0.27
Co	SAMPLE	onsite	community garden
	A	0.80	0.70
	B	1.82	0.19
	C	1.08	0.90
	D	0.80	0.24
	E	0.97	0.90
Cr	SAMPLE	onsite	community garden
	A	1.50	1.83
	B	7.89	0.03
	C	1.85	1.77
	D	0.20	0.12
	E	2.31	0.33
Cu	SAMPLE	onsite	community garden
	A	15.20	8.10
	B	42.76	0.88
	C	21.22	16.77
	D	23.66	0.86
	E	39.16	9.49
Ni	SAMPLE	onsite	community garden
	A	3.60	4.64
	B	6.55	0.36
	C	3.65	4.63
	D	2.57	0.67
	E	5.19	2.86
Pb	SAMPLE	onsite	community garden
	A	21.20	9.65
	B	73.65	0.03
	C	48.89	15.48
	D	44.12	0.84
	E	33.98	70.88
Zn	SAMPLE	onsite	community garden
	A	68.40	76.43
	B	90.10	31.35
	C	61.43	63.22
	D	50.29	41.89
	E	128.13	65.62

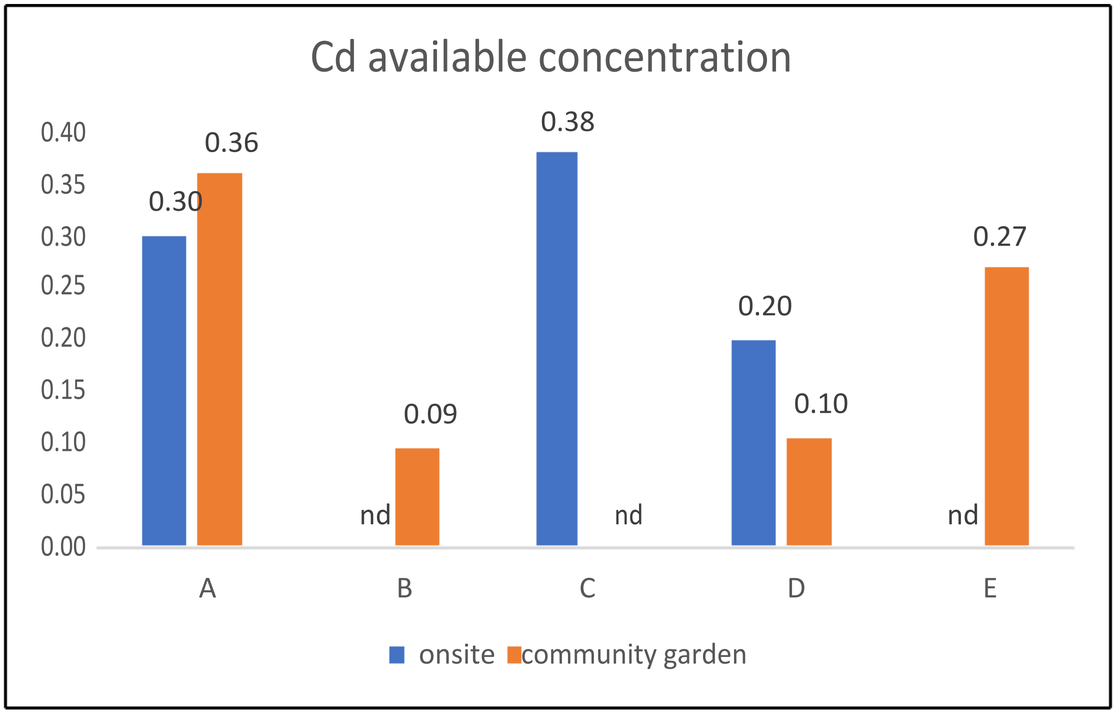

Figure 17. Cd available concentration

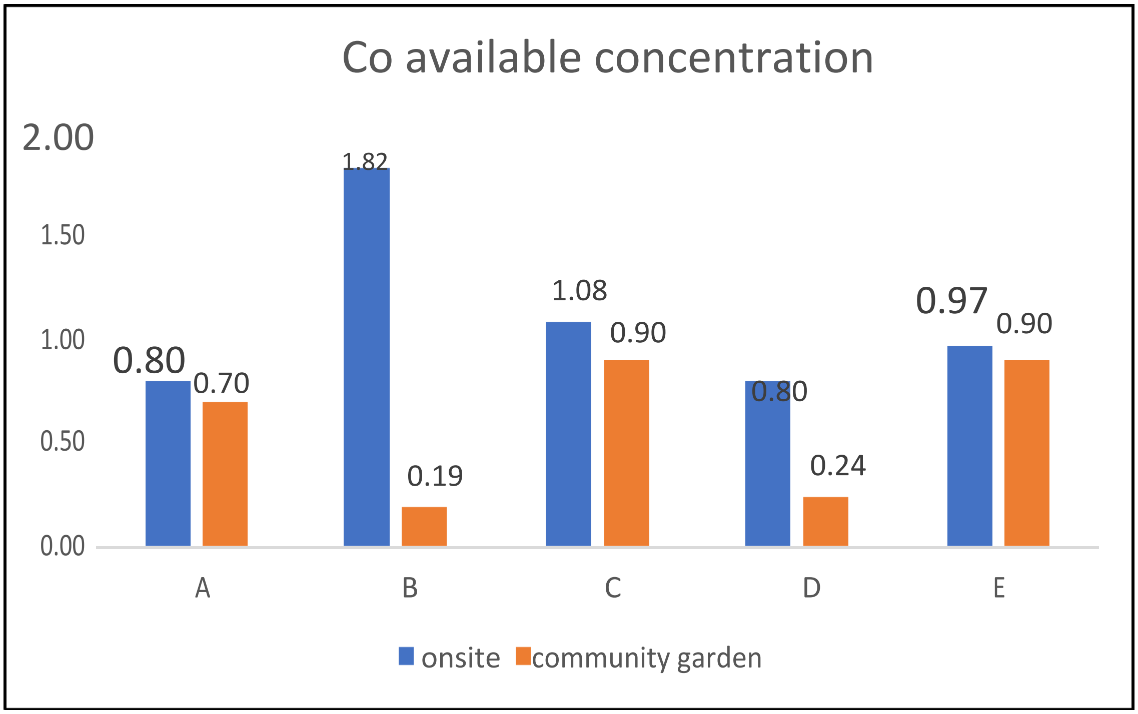

Figure 18. Co available concentration

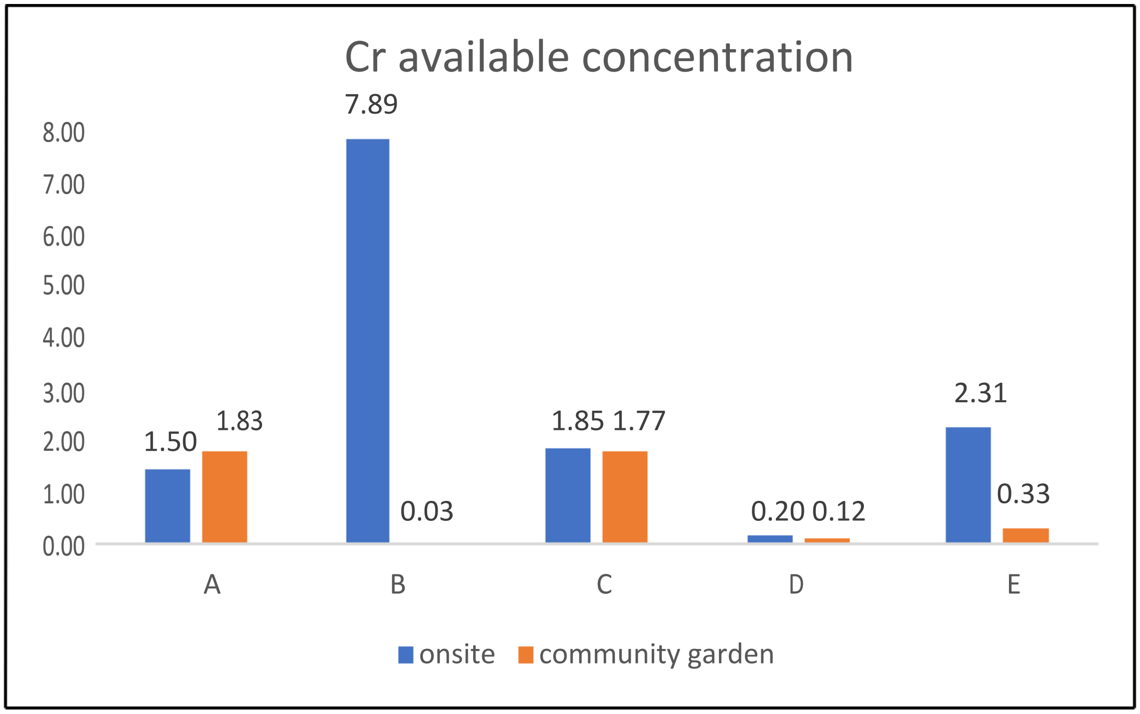

Figure 19. Cr available concentration

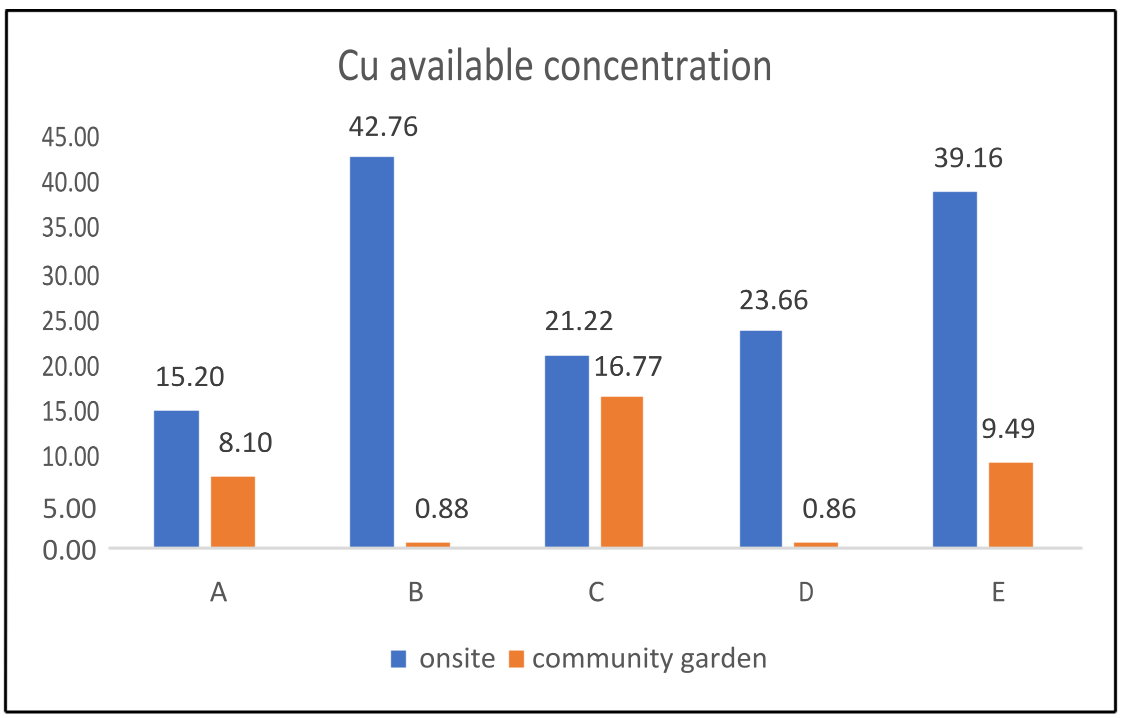

Figure 20. Cu available concentration

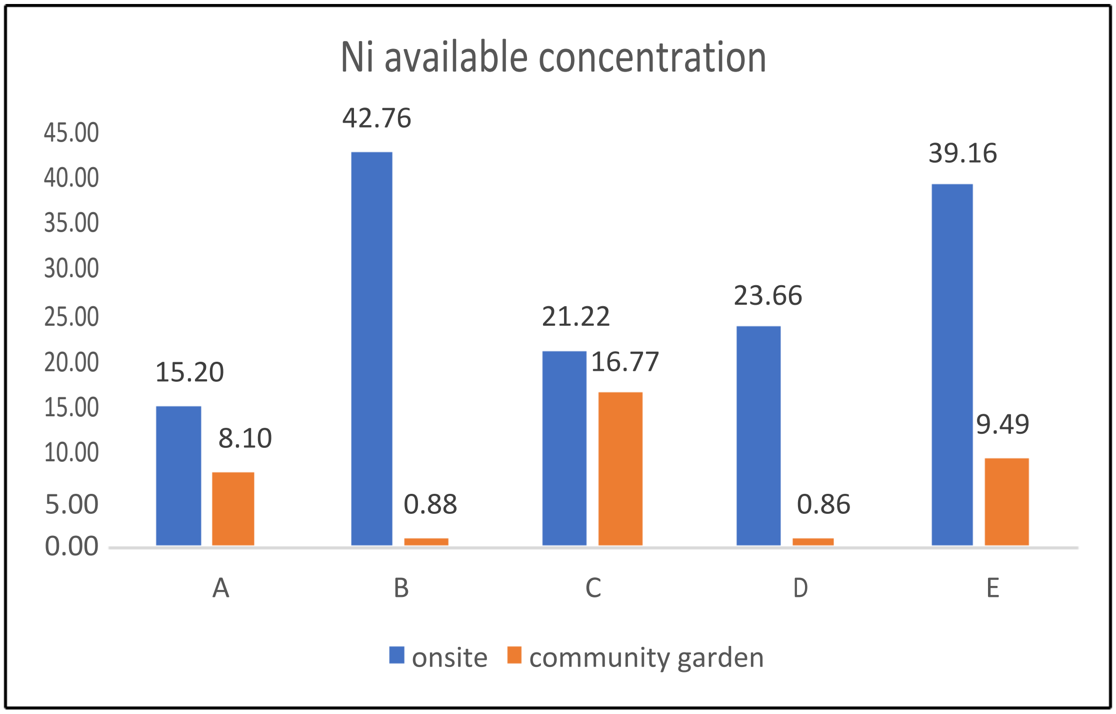

Figure21. Ni available concentration

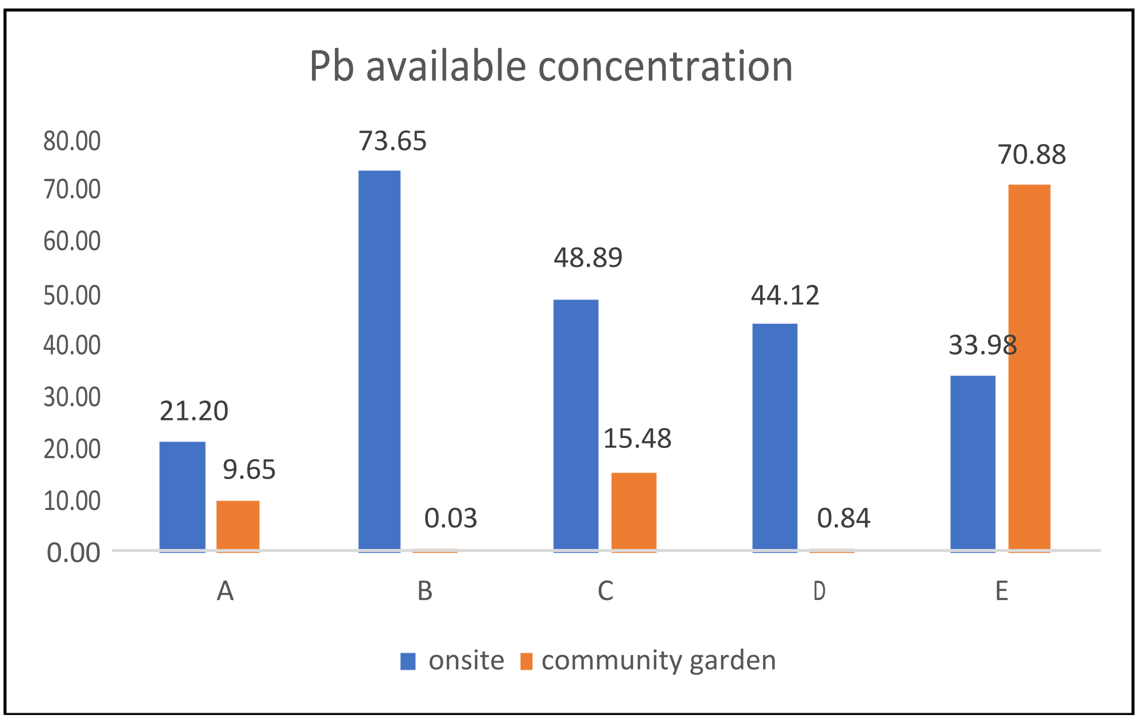

Figure 22. Pb available concentration

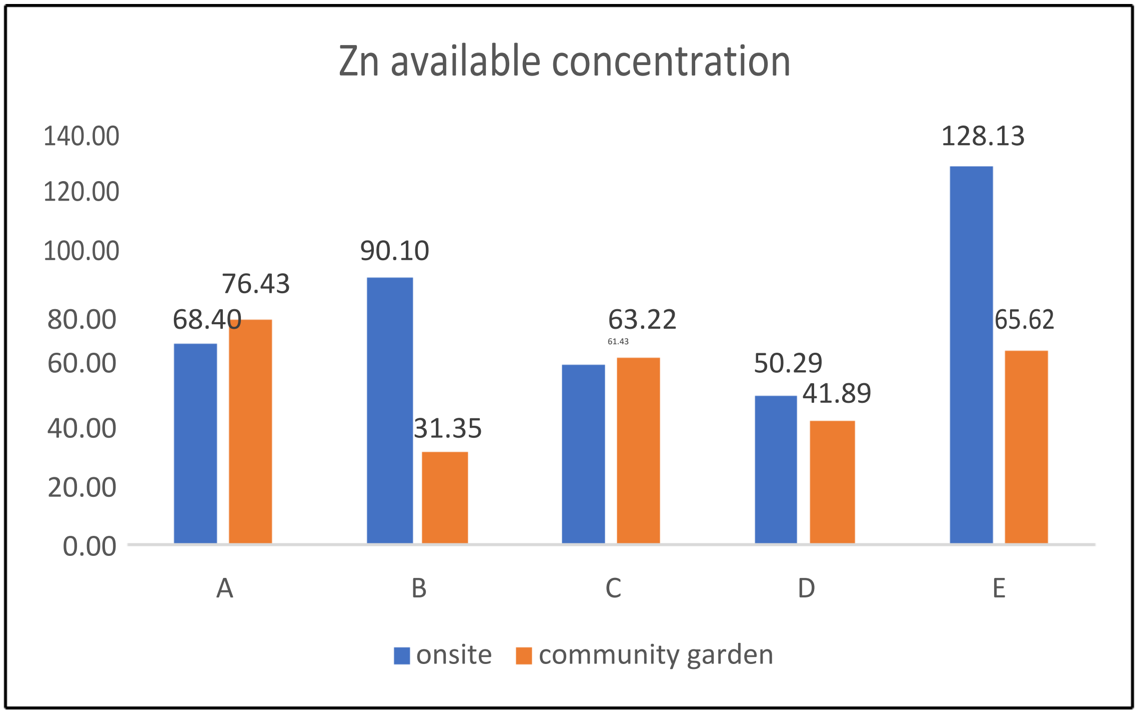

Figure 23. Zn available concentration

One of the major pathways for human exposure to soil contamination is soil-plant-human. Available concentration can represent the potential availability of heavy metal concentration that may be transformed from soil to plants. Overall, the available concentration of the onsite soil is generally higher than the community garden soil, and the difference is most obvious at site B.

6.5 Availability ratio (AR)

6.5.1 Summary statistic

Table5. Availability ratio

	Sample	onsite	community garden
Cd	A	78%	46%
	B	nd	12%
	C	20%	nd
	D	19%	93%
	E	nd	24%
Co	Sample	onsite	community garden
	A	21%	15%
	B	31%	2%
	C	36%	23%
	D	22%	24%
	E	22%	19%
Cr	Sample	onsite	community garden
	A	5%	6%
	B	29%	0%
	C	16%	6%
	D	1%	1%
	E	10%	1%
Cu	Sample	onsite	community garden
	A	34%	11%
	B	69%	1%
	C	45%	27%
	D	34%	4%
	E	83%	12%
Ni	Sample	onsite	community garden
	A	13%	17%
	B	23%	1%
	C	24%	16%
	D	9%	2%
	E	20%	9%
Pb	Sample	onsite	community garden
	A	58%	52%
	B	53%	0%
	C	107%	59%
	D	62%	12%
	E	21%	38%
Zn	Sample	onsite	community garden
	A	48%	27%
	B	35%	13%
	C	43%	34%
	D	34%	31%
	E	82%	22%

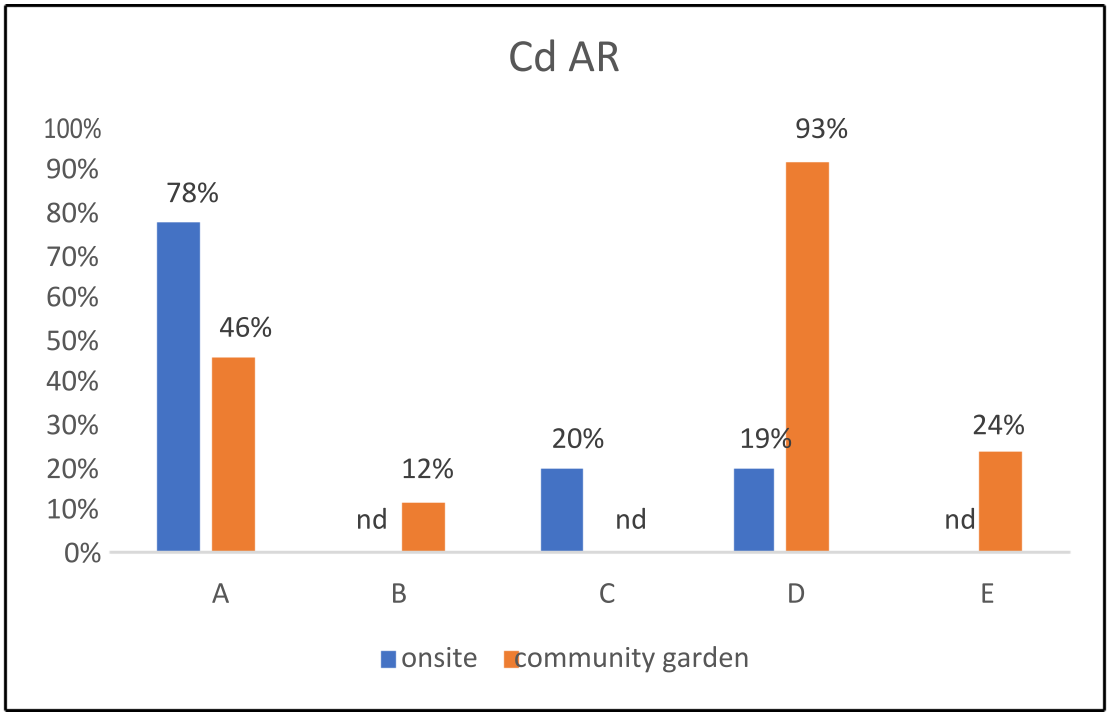

Figure24. Cd availability ratio

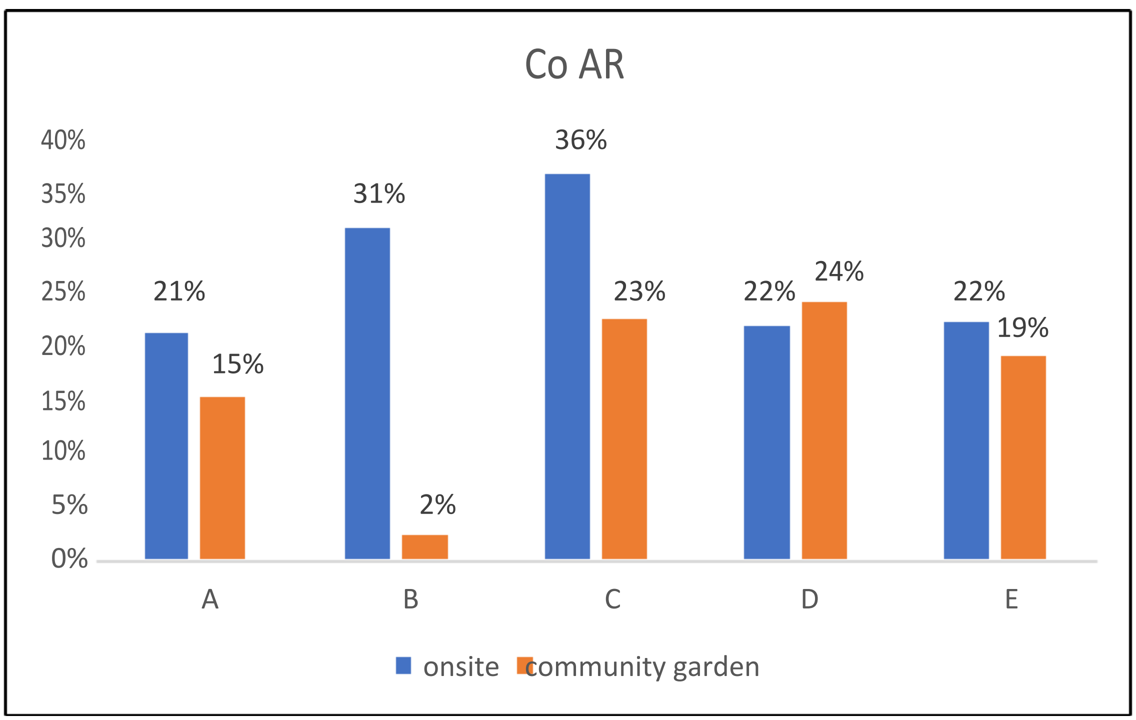

Figure25. Co availability ratio

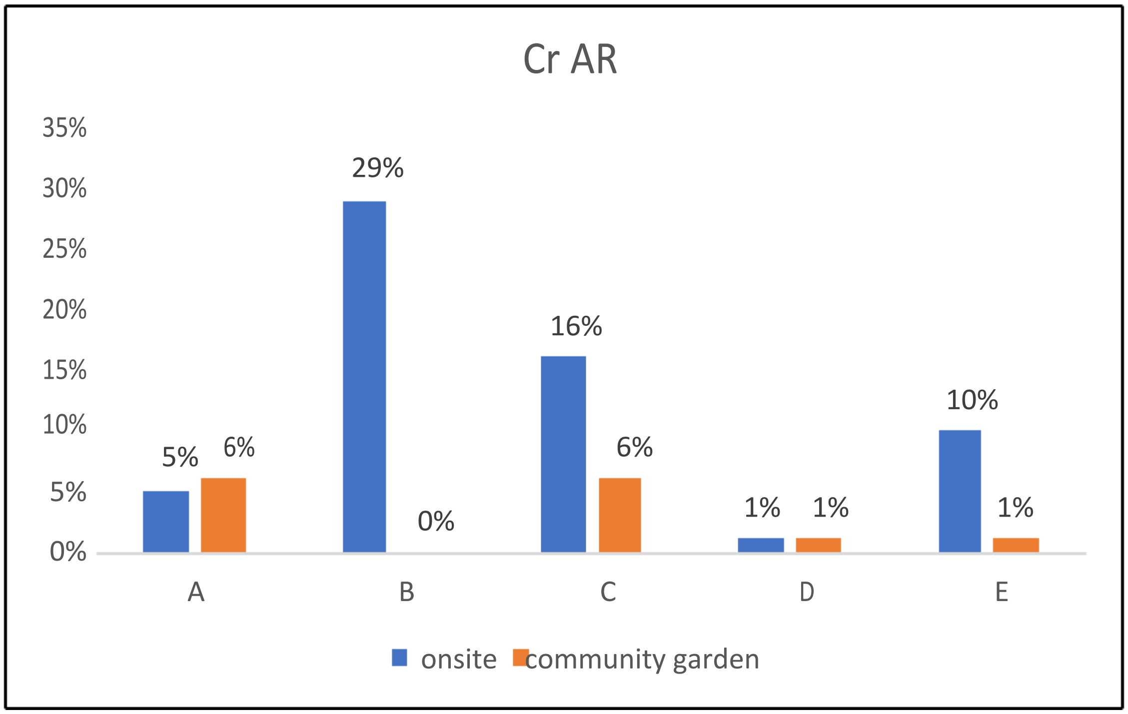

Figure26. Cr availability ratio

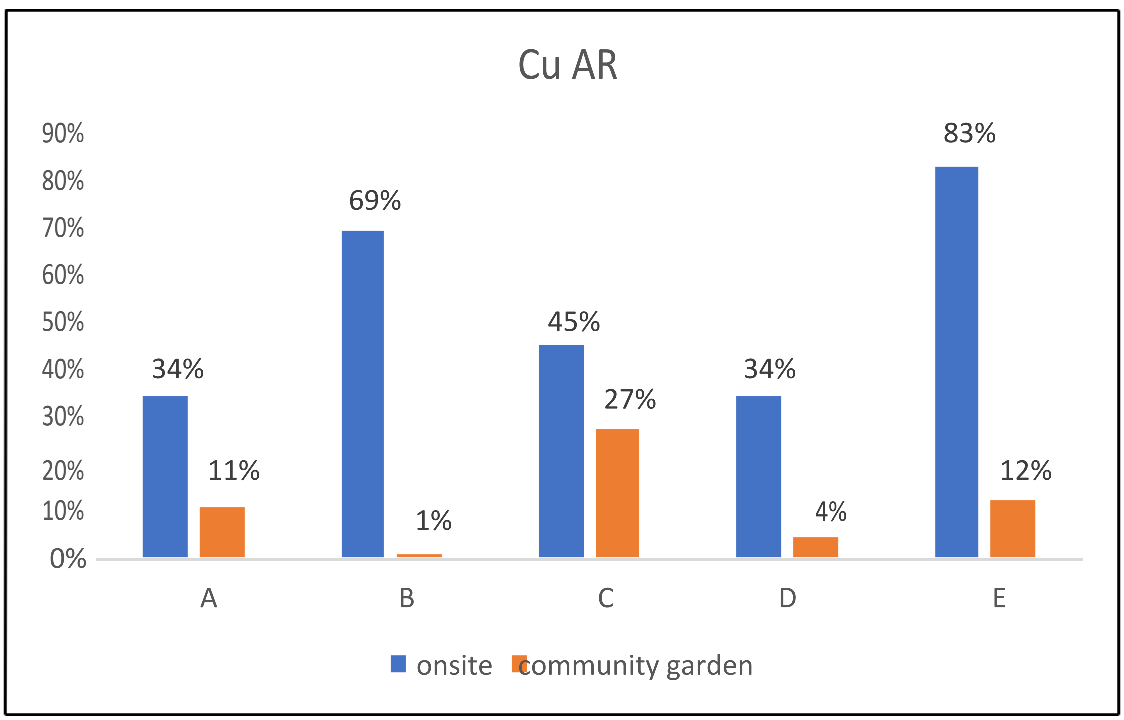

Figure27. Cu availability ratio

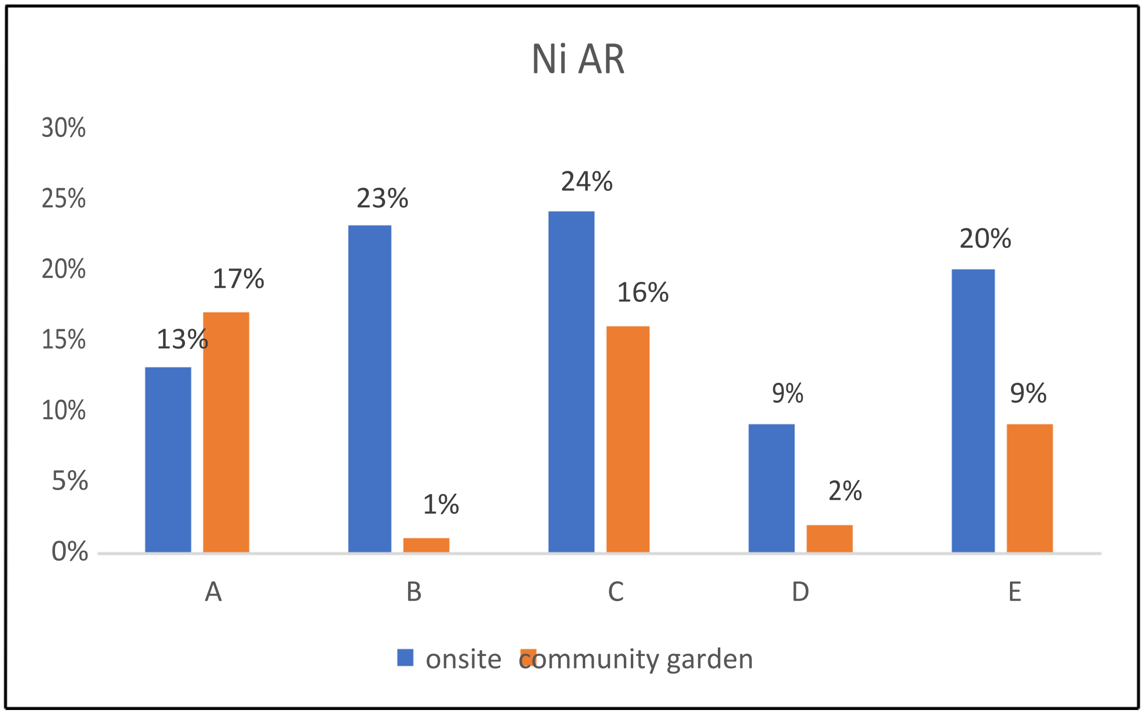

Figure28. Co availability ratio

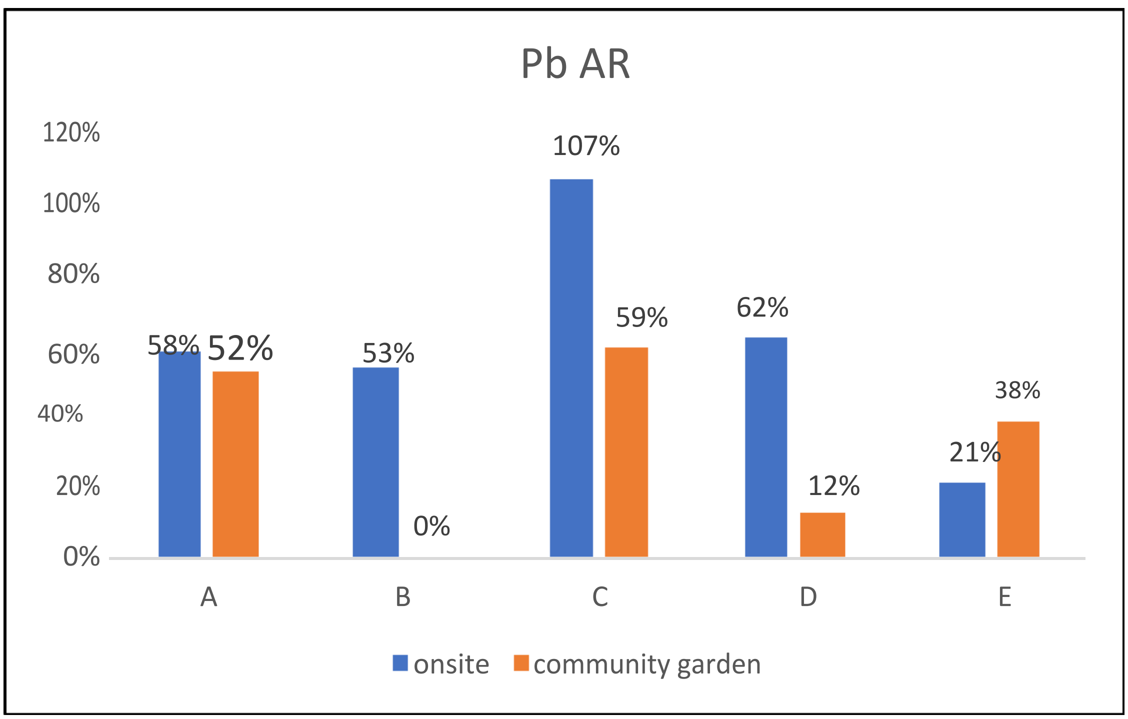

Figure29. Pb availability ratio

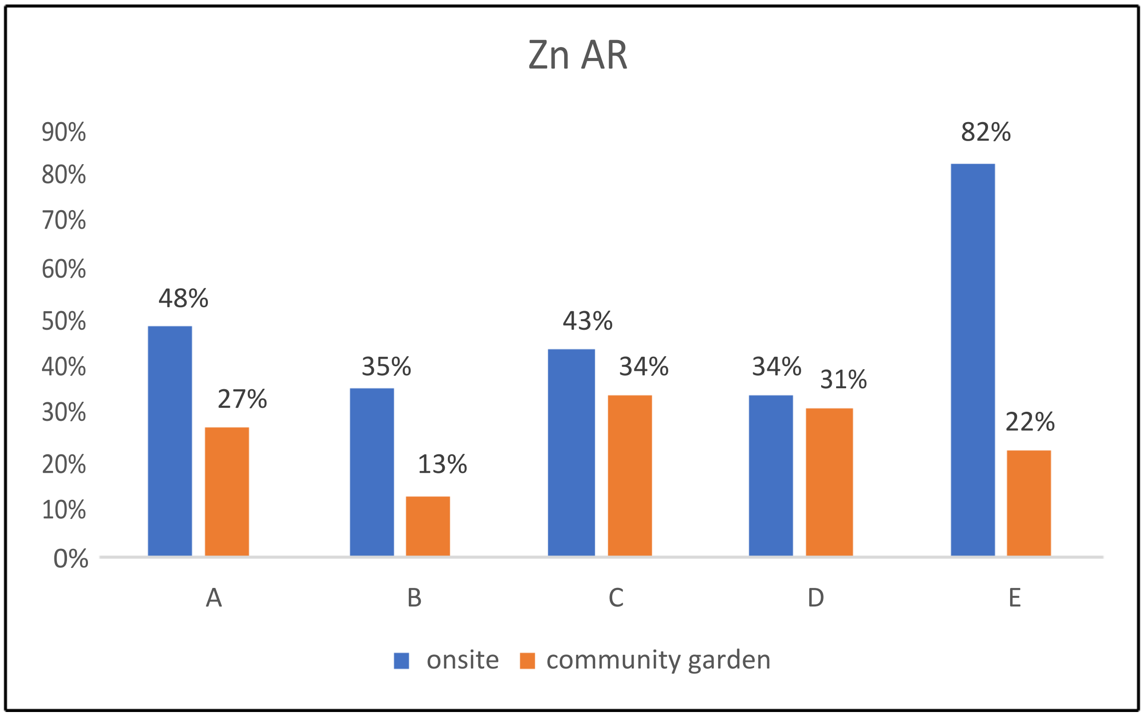

Figure30. Zn availability ratio

As a contamination index, the availability ratio can indicate the site history of soil contamination, and the AR can also reflect the potential human health risks. If the AR is high, it indicates that the possibility of heavy metals transform from soil to plants is also high. This high possibility also suggests a potential health risk of human. According to the figures, the AR of onsite soil is generally higher than that found for the community garden (Massas et al., 2013).

7. Discussion

The objective of this study was to analyze the heavy metal concentrations in soil of the study area. By comparing the total heavy metal concentration with the Canadian Standards, an evaluation was made about the potential health hazard or the heavy metal concentrations. From the results, a summary of the conclusions includes:

1) The concentration of Co, Cr and Ni are all within the acceptable range, especially the concentration of Cr which is much lower than the Canadian Standard.

2) The total concentration of Cd is generally satisfactory, but the onsite soil concentration of site C exceeds the Canadian Standard by 35%. Cadmium is reported to have toxic effects on the kidney, in bones and the respiratory system, Cd is found to be stored in root vegetables (Jarup, 1998).

3) Three samples of Zn exceeded the Standard, exceeding the standard by 14%, 4% and 18%. Zinc is one of the elements that is a required element for human health, but excessive zinc can cause health problems, especially for children. Excessive zinc can cause metabolic disorders, affecting children's absorption of iron, calcium and copper, and affecting children's development (Fosmire, 1990). However, because there is not a high level of excess, the potential harm of zinc to the human body is not serious at this location at this time.

4) The total concentration of lead is not satisfactory. There are three samples that exceeded the Standard, 70 μg/g, and the exceeded values are 139, 159 and 186 respectively above the Canadian Standards, exceeding the standards by 75%, 128% and 165%. Lead can affect several systems of human body, especially children. Exposure to high-concentration lead poses many potential threats to health. Once lead enters the body, it will be distributed in the brain, kidneys, liver and other organs. Lead stored in the bone is more likely to be exposed to the blood during pregnancy (Mudipalli, 2007).

5) According to data and figures (9-16), heavily traffic areas have higher concentrations of metals, especially Pb and Zn. Based on the study of Johansson, Norman and Burman (2009), road traffic emissions contribute to concentrations of heavy metals, and the possible sources of heavy metals are brake wear and exhaust emissions.

As discussed before, the AR can indicate the potential health risk of heavy metal. However, it should be noted that the AR index should be analyzed in context of the total concentration. For example, the AR of site D community garden is almost 100%, but the total concentration is far below the standard, so even though the AR is high, it may not become a serious problem. By comparing the AR and total concentration, all heavy metals are within the Canadian Standards. The AR of some samples are close to 100%, however, once the total concentration increases, there is great possibility for availability concentration to increase as well as the potential risk for human health.

8. Summary results

1) There is no major concern of heavy metal contamination at present time.

2) There is an indication that some metals are approaching and exceeding the Canadian Standards.

3) The data suggests that areas close to heavily traffic areas have higher concentrations of metals, notably lead.

4) In general, the raised beds have the lower concentrations of the metals than the onsite soil.

9. Recommendation:

Although, concentrations are reasonable, it is suggested that community gardeners:

1. Continue to monitor the sites and vegetation as indications of potential contamination.
2. Considerations to be given to bring in soil for raised bed vegetable production, and
3. It is also recommended that all above ground produce be washed before consuming, as there is an evidence that samples near traffic corridor may contribute to contamination form atmosphere deposition.

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